Aquatic Ecosystems

Objectives
Students will: (1) identify components of the ecosystem, (2) describe connections between elements of the ecosystem, (3) discuss hypothetical changes in the ecosystem and the effect of the change, (4) identify how energy flows through the aquatic ecosystem.

Curricular Areas
Science and Language Arts

California Content Standards
Grades 2-5

Science

2nd Life 2 c; Earth 3 c, e; Investigations 4 a, d
3rd Life 3 a, b, c, d; Investigations 5 b
4th Life 2 a, b, c; 3 a, b, c, d; Investigations 6 a, c, d
5th Earth Science 3 a, b, c, d, e
6th Earth Science 4 a; Ecology 5 a, b, c, d, e; Resources; 6 a, b, c; Investigations 7 a, d, e, h
7th Evolution 3 a, d, e

Social Sciences

2nd 2.4
3rd 3.1
4th 4.1, 4.5

English Language Arts

2nd Speaking 1.0
3rd Speaking 1.0
4th Speaking 1.0
5th Speaking 1.0
6th Speaking 1.0
7th Speaking 1.0

Method
Using a web activity, students will become a part of an aquatic ecosystem. They will explore the myriad of interactions within it and ultimately make hypothetical changes to test the idea of interdependence.

Materials
- Time to complete: (1) 50-minute class period
- 300 to 500 feet of twine or string
- Copy and cut apart the "Aquatic Ecosystem Cards." If possible, print the "guess who" answer on the backside of the card.

Background
Plants produce food (stored energy) from inorganic elements and are combined into a group called "producers." Plants use sunlight to provide energy for the chemical process, called photosynthesis, that takes place within their cells. The raw materials for this process are carbon dioxide and water. The oxygen that is produced is a waste product. The food energy they produce is stored in themselves.

The producers form the base or bottom of the food chain or food web. Animals that eat the producers or other animals are called "consumers." Consumers that eat only plants are called herbivores (from the Latin root meaning "grass-eating"). Animals that eat other animals are called carnivores (from Latin for "meat-eating"). Some animals eat both plants and animals and are called omnivores (Latin for "all"). The general term "predator" applies to an animal that eats another animal. The word "prey" refers to the animal that is eaten. A given animal might be a predator on one species and the prey for another.

At each stage of the food web there is a transfer of food energy, which is used for many different things. It may be used for growth, reproduction, waste, respiration, and some is stored as fat or oil. Consequently, each level of the food web above the level of the producer has less available food than the level below it.

Procedure
1. Read John Muir's quote: "When you try to change a single thing, you find it hitched to everything else in the universe."
2. Ask students to share their ideas about what Muir meant. Do the students agree?
3. Explain that in this activity, each student will become a part of a system that includes plants, people, animals, and their environment (an ecosystem).
4. Have students sit in a circle. Pass out the "Aquatic Ecosystem Cards" and ask them to hold them so that everyone in the circle can see them.
5. Stand in the center of the circle with the twine or string. Starting with the sun, have each student read the information on the card (a copy of the script is included if teacher or other strong reader needs to assist). Each student's part will end with a question for the class to discuss and answer. The

answer chosen will determine which student will read their information next. The student reading the information is responsible for making sure the class answers correctly (answer should be printed on the back of the card).

6. Make the web with the string, and follow the path of the students reading and answering questions. The reader holds on to the string as it is passed to the next reader. Continue to unwind the string until everyone is holding onto the string. The teacher may need to aid in the passing.
7. Once the web is complete, discuss the following questions (keep the web intact).

Questions:

1. Are components of this ecosystem connected?
2. Does the pattern created by the string remind you of something? (Connections in an ecosystem are complex, more like strands in a spider web than the links of a chain.)
3. What if? Questions:
   a) As plants and animals die in the ocean, they sink to deeper depths where they decompose and create nutrient-rich water. Winds blowing surface water away from the shore allow the colder, nutrient-rich water to rise from below. This cold-water upwelling brings important nutrients to the surface, causing plankton "blooms" or population increases. However, sometimes warm-water currents (e.g. El Niño) interfere with this cold-water upwelling. This means that nutrient-rich water is not available to the plankton. Let's say that our ecosystem is experiencing El Niño conditions. What will happen to our plankton? Who depends on plankton for food? (answer: krill) Who depends on krill for food? (answer: adult salmon in the ocean) If there is less food available for adult salmon in the ocean, all the life stages of the salmon will be affected. Raise your hand if you represent salmon at any stage. Just those people give two short, gentle tugs on the twine. Who felt it? How would you have been affected by the change in salmon?
   b) California often experiences times of lower rainfall. In these times of drought, there is less water available to an ecosystem. Let's say that our ecosystem is experiencing a drought. Raise your hand if you represent water in some form. Just those people give two short, gentle tugs on the twine. Who felt it? Is there anyone who was somehow not affected by the drought?
   c) Let's take a look at our policymakers. What would happen if they decided not to put any limits on when and how many salmon could be caught? What might happen to the number of salmon in the ocean? Remember, if there are fewer adult salmon, then there are fewer salmon at every life stage, so anyone who represents salmon gives two tugs on the twine. Who feels the effect? How?
   d) Now let's say that way up in the mountains, a forest is improperly logged. When the rains come, much soil and debris are washed into the stream. This sediment in the water eventually settles on the river bottom. If it settles on salmon or steelhead eggs, how would they be affected? How would this affect other parts of the ecosystem?
4. (Start rolling up the twine at this point or have the class put it down.) Does John Muir's quote apply to this ecosystem?
5. Are people a part of the ecosystem?
6. What negative effects could people have on the system?
7. How could negative effects be minimized?
8. What positive effects could people have?
9. Were all of the changes that we discussed caused by humans? Which ones were not? Can you think of other changes that might be caused by nature?

Evaluation

- Describe at least three connections between elements of that ecosystem.
- Describe a hypothetical change that could occur in the ecosystem and explain its effect.
- Discuss the roles that humans can play in that ecosystem.
- Describe how energy flows through an aquatic ecosystem and give an example.

Activity reprinted with permission from *Some Things Fishy, A Teacher's Guide for the Feather River Fish Hatchery,* published by the CA Department of Water Resources, Office of Education.

Master Script

I am the **sun**. Plants use my energy to make food, even simple water plants like...Guess who?

I am **algae**. In the water, I grow on the bottom, rocks, and other things, or float, depending on my kind. When I make food from the sun's energy, I use some to stay alive, but some is stored. I am eaten by tiny water animals called...Guess who?

I am a **water flea**. I use some of the energy I get from plants, such as algae, to live, but some I store. I am a source of food, and therefore energy for this small fish...Guess who?

I am a **perch**. I use the energy I get from eating water fleas and insects to swim and stay alive, but I store some of the energy in my muscles, body fat, and other body parts. When small, I am food and an energy source for this amphibian... Guess who?

I am a **bullfrog**. The energy I get from eating fish and other animals helps me to stay away from predators who might try to eat me for energy, such as this reptile...Guess who?

I am a **garter snake**. Although I am a predator, I am also prey. I could easily become food energy for this long-legged wading bird...Guess who?

I am a **great blue heron**. I feed along the edges of waterways by day, but at night I like to roost high up in a...Guess what?

I am a **cottonwood tree**. I am only found in areas where my roots can always get water. That is why I am so common along these waterways...Guess where?

I am a **river**. Water that flows along my path can be traced from high in the mountains all the way to the ocean. I am a highway for these fish that swim upriver to spawn (reproduce)...Guess who?

I am a **spawning salmon**. When I am an adult, I swim upriver until I reach a place to spawn. Female salmon spawn by laying eggs. Male salmon spawn by fertilizing the eggs so that they can become fish. Spawning is the end of my life cycle. Not long after I spawn, I become a...Guess what?

I am a **dead salmon**. When I swam upstream to spawn, I stopped eating and put all of my energy into reproducing. The condition of my body gradually worsened until I died. I still play a very important role. My decomposition adds nutrients to the stream. I become food for lots of plants and animals, such as this relative of a crab...Guess who?

I am a **crawdad**. I look like a small lobster and also feed on small fish, snails, and insects. I am food for this playful aquatic mammal...Guess what?

I am a **river otter.** I rely on crawdads as one source of food. One of the requirements for my habitat is that I have plenty of this...Guess what?

I am **unpolluted river water.** I carry lots of nutrients to plants and animals that live in and around me. I also have molecules of this gas dissolved in me...Guess what?

I am **oxygen**. Fish use their gills to take me out of the water, but I am also absorbed by these small, round living things that will eventually become a fish...Guess what?

I am **salmon eggs**. As my parents traveled upstream, they were followed by a fish that eats me for energy. Part of its name even sounds like an animal that would steal eggs...Guess who?

I am a **steelhead**. I am a rainbow trout and I spend part of my life in the ocean. I am a very popular sport fish for these humans who try to catch me for recreation...Guess who?

I am an **angler**. Some people call me a fisherman, but since women like to fish too, the word angler includes everybody. I make sure that I am a good sport by following special rules designed to protect the fish. Also, if I am over sixteen years old, I have to buy one of these permits that allow me to fish...Guess what?

I am a **fishing license**. Some of the money anglers pay for me is used to improve the places where fish spawn. One form of improvement of restoration involves adding these small rocks to a river or stream... Guess what?

I am **gravel**. Spawning salmon and steelhead look for a gravel bed in just the right place. Their eggs will have a safe place to develop until they hatch and become...Guess what?

I am **salmon or steelhead fry.** In two to five years, I will return to this gravel to spawn. If there is not enough spawning area in my home river, sometimes I develop in these human-made fish nurseries...Guess what?

I am a **fish hatchery**. I am often built along a river because one of these human-built structures blocks fish from traveling upstream to their former spawning beds...Guess what?

I am a **dam**. I was built to collect and store water for all kinds of uses. One group of people use the water stored behind me to grow their crops...Guess who?

I am a **farmer.** Although I depend on water from dams, the original source of that water is something I really depend on... Guess what?

I am **rain and snow**. I come from clouds that form as water evaporates from the earth. My biggest source of moisture is this huge body of water...Guess what?

I am the **ocean**. I am home to thousands of kinds of plants and animals. Some animals, such as salmon and steelhead, spend only part of their life living and feeding in my waters. In fact, this is where many adult salmon are caught by these people who make their living from fishing...Guess who?

I work in the **commercial fishing industry**. A group of people decide how long I can fish each year and how many fish I am allowed to catch...Guess who?

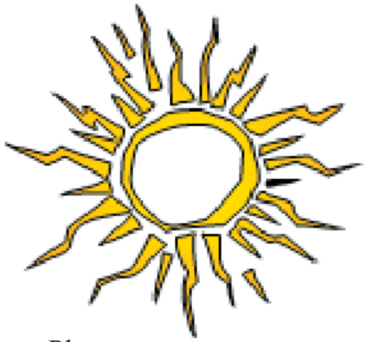
I am a **policymaker**. I consult with biologists when I write fishing regulations. The number of this large fish left in the ocean is affected by my decisions...Guess who?

I am an **adult salmon.** Policymakers' decisions do have an effect on our population size, but so does the amount of food available to us in the ocean. One of our major sources of food is this shrimp-like animal...Guess who?

I am **krill**. Although only about an inch long, I am the food for many ocean animals including many whales. My food is the soup of the sea...Guess who?

I am **plankton**. Animal plankton is called zooplankton, and plant plankton is called phytoplankton. Like other plants, phytoplankton depends on this energy source to make its own food...Guess who?

The **sun**. The END (and the BEGINNING).



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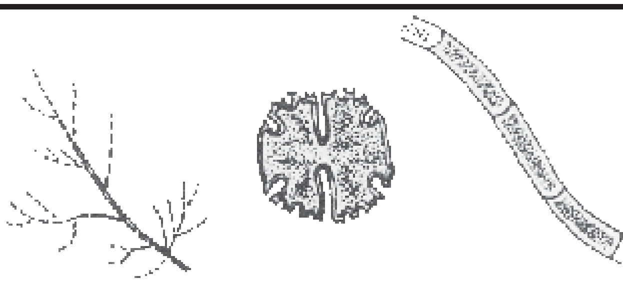

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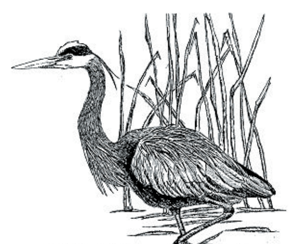
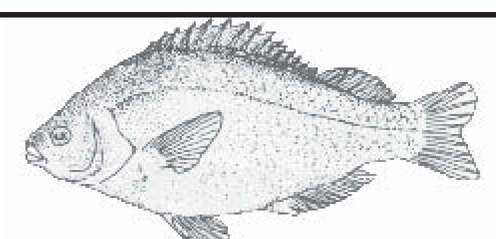


USFWS, TimothyKnepp



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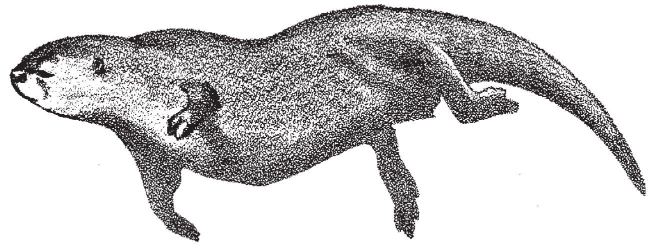

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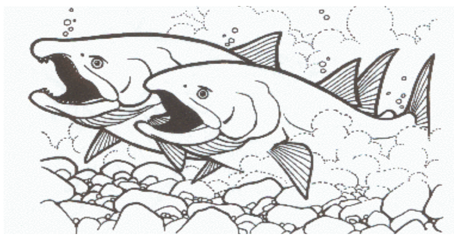

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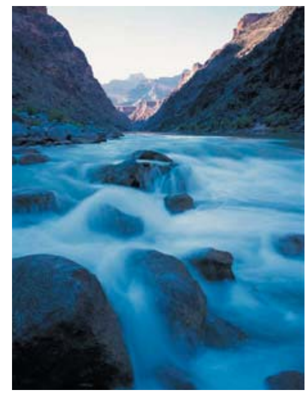

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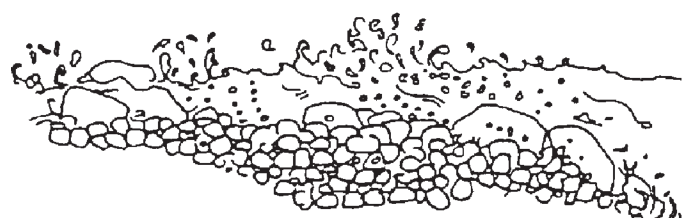

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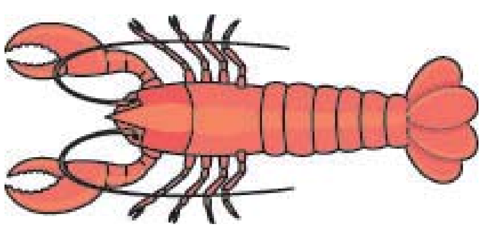

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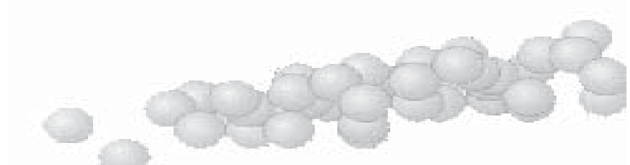

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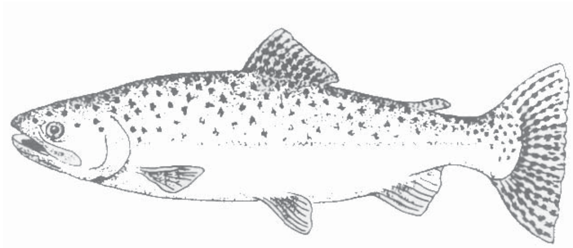

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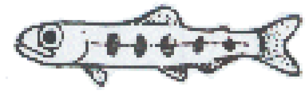

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USFWS, Paul Kerris

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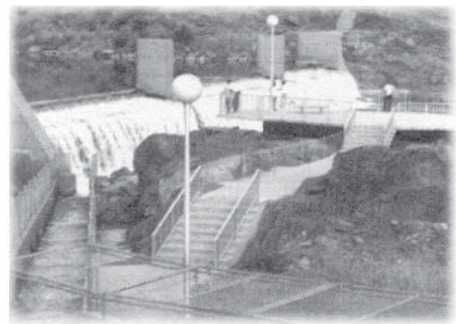

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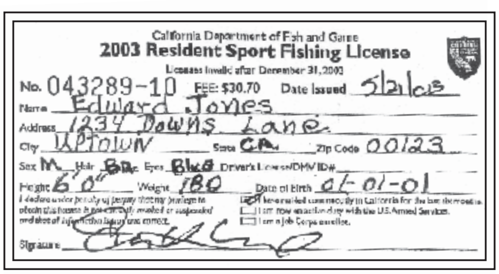

California Department of Fish and Game
2003 Resident Sport Fishing License
Licenses invalid after December 31, 2003
No. 043289-10 FEE: $30.70 Date Issued 5/21/03
Name Edward Jones
Address 1234 Downs Lane
City UPTOWN State CA Zip Code 00123
Sex M Hair Br Eyes Blk Driver's License/DMV ID#
Height 6'0" Weight 180 Date of Birth 01-01-01
I declare under penalty of perjury that my privilege to obtain this license is not currently revoked or suspended and that all information is true and correct.
☑ I have resided continuously in California for the last six months.
☐ I am now on active duty with the U.S. Armed Services.
☐ I am a Job Corps enrollee.
Signature

I am a **fishing license**. Some of the money anglers pay for me is used to improve the places where fish spawn. One form of improvement of restoration involves adding these small rocks to a river or stream... Guess what?

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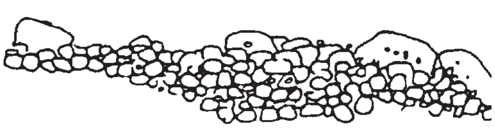

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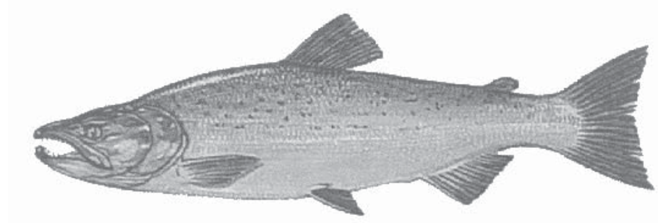

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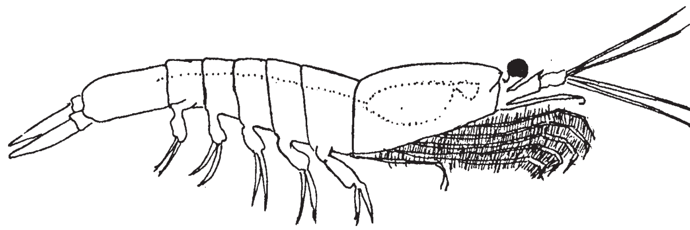

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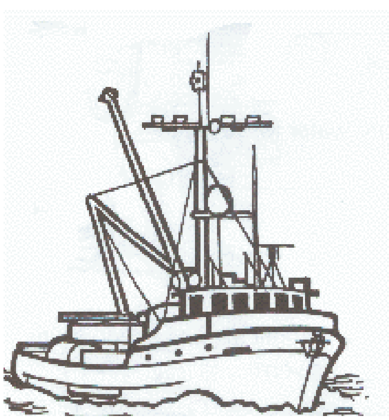

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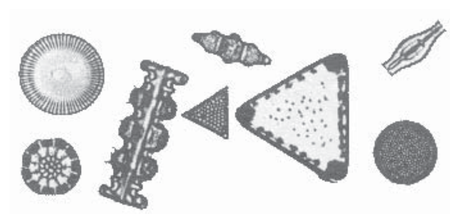

I am **plankton**. Animal plankton is called zoo-plankton, and plant plankton is called phytoplank-ton. Like other plants, phytoplankton depends on this energy source to make its own food...Guess

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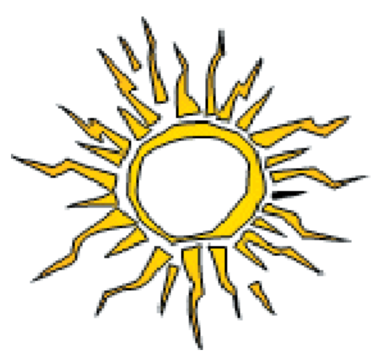


Aquatic Connections

Objectives

In this series of three interrelated activities students will: (1) explain how food availability is a limiting factor, (2) identify feeding relationships and the transfer of energy among plants and animals, and (3) discuss human activities which affect the food web in an aquatic environment.

Curricular Areas

Science (organizing, inferring, predicting, experimenting, communicating), Math (averaging, graphing), English Language Arts

California Content Standards

GRADES 3-8

Science

3rd Life 3 a, c, d; Investigations 5 a, c, d, e
4th Life 2 a, b, c; 3 a, b, c, d; Investigations 6 a, c, d, e
5th Life 2 f, g; Investigations 6 c, g, h
6th Earth 3 b; Ecology 5 a, b, c, d, e; Resources 6 a, b, c; Investigations 7 a, c, d, e
7th Living Systems 5 g; Investigations 7 c, e

Math

3rd Numbers 1.0, 2.0; Data 1.0; Reason 1.0, 2.0, 3.0
4th Numbers 1.0; Data 1.0, 2.0; Reason 1.0, 2.0, 3.0
5th Numbers 1.0; Data 1.0; Reason 1.0, 2.0, 3.0
6th Data 1.0, 2.0, 3.0; Reason 1.0, 2.0, 3.0
7th Data 1.0; Reason 1.0, 2.0, 3.0

English Language Arts

3rd Speaking 1.0
4th Speaking 1.0
5th Speaking 1.0
6th Speaking 1.0
7th Speaking 1.0

Method

The concept of food webs is communicated to students with a simulation of natural systems. Students will model animals in search of food. Three activities are used in this simulation; each activity builds on the experience from the previous one.

Materials

- Time to complete: (3) 50-minute class periods.

For each student:

- 10 markers, 15 for second game (poker chips, beans, pennies or other non-destructible small items)
- small plastic bag

For the teacher:

- 2 data sheets and a clipboard
- pencil

Background

In every ecosystem components are linked by the transfer of food energy called the food chain or food web, because it is not as simple as a straight chain. Plants or producers form the base or bottom of the food web. Animals that eat producers or other animals are called consumers. Consumers that eat plants are called herbivores (Latin meaning "grass-eating"). Animals that eat other animals are called carnivores (Latin meaning "meat-eating"). Some animals eat both plants and animals and are called omnivores (Latin meaning "all"). The general term "predator" applies to an animal that eats another animal. The word prey refers to the animal that is eaten. A given animal might be a predator on one species and the prey of another.

Energy is used at each stage of food transfer. Some is used for growth or is stored as fat or oil. Some is used for reproduction. Some is waste, such as undigested material lost in feces or the bodies of dead organisms. Much of the food that an animal eats is broken down in a process called respiration that takes place inside body cells.

Human activities may affect food chains in many ways. Pollution and habitat destruction cause obvious changes that are easy to see. However, more subtle changes may result from extensive harvesting or removal of specific levels of the food chain. When some fish are selectively removed, it may have a significant impact on other animals and on the plants in a watershed. Very careful planning is necessary to be able to either remove or add animals in a system without disturbing the ecological balance of the entire system.

Procedure

This activity has three parts, with each part building on the previous one. Teachers may choose to do one or all three parts. Each part will require one class period.

Before class (same for all parts):

1. Plan the location for the activity, including an alternate site in case of rain if you are planning to do it outside. This exercise works best in an open space.

Part I

Carrying Capacity - the relationship of food availability to the number of herbivores an area can support

2. Review terms *zooplankton* and *phytoplankton*. Zooplankton feed on the tiny phytoplankton that drift through the surface water in an aquatic environment. Explain that the students will be zooplankton searching for phytoplankton to eat. What happens when herbivores have to compete for food? Have students predict what might happen if they do not get enough to eat. Will they starve and die? Will they have any offspring?
3. In this exercise, the river has a limited number of phytoplankton and only a few zooplankton. The food supply will stay the same from one generation to the next. The beans or poker chips represent phytoplankton. To start, designate 2/3 of the class as zooplankton and give each student a plastic bag to collect phytoplankton. The rest of the class is reserved for the next generation.
4. Scatter 10 food items per student. Tell students to eat as much as they can without taking any away from another zooplankton. Begin the food search and let students pick up all the food. It will be over pretty fast.
5. Have everyone sit down. Did they all get the same amount of food? Some individuals are more efficient searchers than others. Record the results on a data sheet.
   - Herbivores with fewer than nine phytoplankton starve to death.
   - Some of the zooplankton did not get enough food to reproduce.
   - Those that have nine to eleven left one offspring.
   - Those with twelve or thirteen phytoplankton have two offspring.
   - More than thirteen leave three offspring.
6. Repeat the game.
7. After reproducing, the parents die, leaving behind the number of offspring indicated on the data sheet, which are the zooplankton of the next generation. Change the number of players to match the number of offspring.
8. Recruit from the reserve and allow substitutions for tired “zooplankton.” Scatter the same number of food items as the first game regardless of whether the number of players went up or down. Assume the same number of phytoplankton will be produced.

The amount of food is limited.

9. Run the game again and calculate the results. Repeat. If possible, do four or five generations. You should find that as long as the food supply remains the same, approximately the same number of animals are produced in each generation.

During class:

10. Put the results of the simulation on the board. Have the students discuss what happened. Consider the following questions:
    - Did all the zooplankton get enough to eat? Even though there was food enough for everyone to survive, some were better at competing for food.
    - What happened to those that had more food? The best competitors had the most offspring.
11. Review the conclusions. Animals compete for food. Those that do not get enough to eat die, or are caught by predators because they are weak or diseased. Those that compete most successfully leave more offspring. If the limit to the number of herbivores in an area is the food supply, their number remains more or less the same from one reproductive period to the next if the food supply remains constant. This average number of animals is the *carrying capacity* for that habitat.

Part II

Predator-prey: the feeding relationships among animals that live in a river

1. In this part of the activity, the class is going to be the animals in a river. Have students name some animals that live in the river. Some answers might be big and little fish, frogs, crayfish, tiny zooplankton, insects, beavers and raccoons. Have pictures of river animals to show the class.
2. In the river, where does the food come from? From plants which use light to do photosynthesis. Some of these plants are tiny phytoplankton while others are rooted green plants that grow under the water or along the edge of the pond. Write the words *phytoplankton* and *green plants* at the bottom of the board.
3. Introduce the word *producers* for those things that make food. Who might eat these plants? The tiny animals called zooplankton eat phytoplankton as the students learned in the previous part. Many insects and the crayfish feed on plants as do the beavers. Write *insects*, *crayfish*, *beavers* and *zooplankton* above the plants on the board and draw an arrow up to them.
4. Explain you are drawing a diagram of the path food takes in the river. Those animals that eat plants are called *herbivores*.
5. Who eats the herbivores? (Answer: little fish and frogs as well as some bigger fish.) Add them to the next level along with an arrow. Animals that eat other animals are called *carnivores*. The animals that get eaten are called *prey*.
6. Finally, who eats the carnivores? (Answer: the big fish and the raccoon, or the *top carnivores*.) They do not just eat the level below them, they also eat the crayfish from the lower level.
7. Can the students see the *food web* or *food chain* forming as you draw the lines between the levels? (One way to illustrate the web is to pass out cards with the names of different animals and have the students pass a ball of yarn from the persons with the lowest levels of the food chain or web to those higher up.)

8. Now for the game, have students go to the activity location. In this game they will be animals in a river food chain feeding on each other.
9. The food plants or phytoplankton (poker chips or large white beans) are scattered over a wide area. In this game food is not limiting, thus there are more plants than the herbivores can eat.
10. 1/3 of the class will be zooplankton, crayfish and insects. Give them the same colored strip of cloth to wear and a plastic bag. They are all *herbivores*.
11. Scatter 20 food items for each herbivore. That means 20 times one third the number of students. These are the plants in the river. The herbivores need more food to live, and must get 10 pieces of plant food before the end of the game. If they do not get 10 pieces, they die of starvation.
12. Give another 1/3 of the class a second color armband and a plastic bag. They are the *carnivores*, such as frogs and small fish. To eat, they must tag a herbivore. The herbivore gives up his food bag and sits down if he has been "eaten" by the predator, and therefore is out of the game. The predators must collect 20 pieces of food from the herbivore food bags to be alive at the end of the game. They must stop eating when they have 20 pieces. If they do not get 20 pieces, they die of starvation.
13. The remaining students are the *top carnivores*. They get the third color of cloth and a plastic bag. They feed by tagging either the herbivores or the carnivores who must give up their bags and sit down when tagged because they have been "eaten." The top carnivores need 40 pieces of food to be alive at the end of the game. They should stop eating when they have passed 40 food items.
14. Caution the students about rowdy behavior and running into each other. Give them 5 minutes to find food then stop the game. Record the results.
15. Change the number of students in each level. Assign 1/2 of the class to be herbivores, 4 or 5 students to be top carnivores, and the remaining students will be carnivores. Repeat the game for 5 minutes. Stop and record the results.

During class:

16. Analyze what has happened for each playing of the game. Record the results on the board.
    - Do the students think either of these worked like a real river food chain?
    - What was the cause of death in most cases for the herbivores? For the carnivores?
    - In each game,were the proportions the same at the end as the beginning?
    - What levels of the food web do they think should have the most animals?
17. The proportions in the first game were intentionally wrong. They were chosen because they do not work. The students should be able to see the lack of balance. The top carnivores are going to eat all their prey. With none left to reproduce, the top carnivores will starve to death. If all the herbivores get eaten, they will not leave any offspring, and the rest of the levels will starve to death in the future. The second game should provide information and help students develop inferences about food levels. The numbers at each level should be more like a standard pyramid.
18. Discuss the conclusions. In order for the food web or chain to be realistic, the students must have some individuals from each level alive at the end of the model. These animals will be the ones that reproduce, making the next generation.

Part III

Human activities that change the feeding relationships, and thus the ecological balance, of a food web.

1. Explain that this is a continuation of the food chain experiments conduced in Parts I and II. The question for this part is, "What impact do humans have on the balance of a food chain?" Ask students to name some ways people might affect the animals in the river food chain. Ask students to identify the food web of the river model from the previous game. Draw the food web on the board as students name the

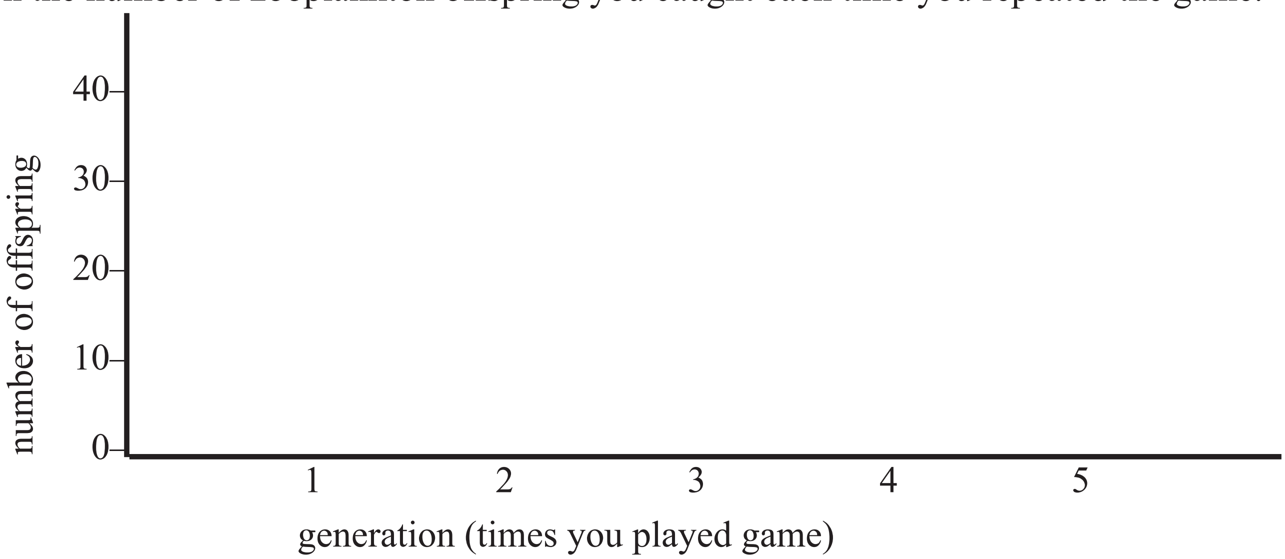
Activity adapted from *Living in Water Activity Guide* food chain section, written by Dr. Valerie Chase for National Aquarium of Baltimore, Baltimore, Maryland 21202.

Aquatic Connections Worksheet

Part I

	# at beginning	# starved	# with 1 offspring	# with 2 offspring	# with 3 offspring
Round 1					
Round 2					
Round 3					
Round 4					

Graph the number of zooplankton offspring you caught each time you repeated the game.



Calculate the average number of offspring in the population by adding the numbers from each generation together and then dividing by the number of generations you had.

Part II

FIRST RUN

feeding level	# live at beginning	# eaten	# that starved	# alive at end
herbivores				
carnivores				
top carnivores				

SECOND RUN

feeding level	# live at beginning	# eaten	# that starved	# alive at end
herbivores				
carnivores				
top carnivores				

Aquatic Food Web